Chapter One: Contents

(Environmental Module Overview – 15 October 2001 – LA-UR 01-5715 – Portland Study Reports)

Chapter One—Environmental Module Overview

The emissions module treats Heavy-Duty Vehicle (HDV), Light-Duty Vehicle (LDV) and evaporative. Figure 1 illustrates the information flow for the module. For both HDVs and LDVs, the output of the Traffic Microsimulator is aggregated into speed bins (in increments of 7.5 meters per second) and spatial segments (30 meters in length) and summed over an hour. LDVs entering each link over each hour are grouped by soak-time (the length of time the engine was off prior to start of the current trip) and by integrated velocity acceleration product. The velocity acceleration product is used as a surrogate for fuel consumption to give the stage of engine and catalyst warm-up. The simulation also provides the distribution of vehicle types that is used to construct the emission arrays.

The microsimulation LDV output is used by the aggregated dynamics module to calculate the number of vehicles for each 4-mile per hour (mph) speed bin and each 20-mph squared per second power bin (more precisely, velocity (*V*) acceleration (*A*) product bin). The Comprehensive Modal Emission Model (CMEM) arrays—one that reflects emissions at constant power and one of that reflects differences in emissions associated with changes in power from one second to the next—are used to estimate the emissions for each speed and power bin. The contributions from each speed and power bin are summed to obtain the emissions. Three sets of empirical data have been used to estimate parameters in the aggregate dynamics model.

- First, during Environmental Protection Agency's (EPA) three-city studies, many vehicles were fitted with a data-logger that recorded times and speeds throughout the vehicle's travels for a significant period. The three-cities data was used to estimate the distribution of high-power events (*V A* product greater than 50.) and hard-braking events (*V A* product less than -50.) by *V A* product.

- Second, the California Air Resources Board (CARB), supported the collection of vehicle trajectories on freeways and arterials with different levels of congestion. A portion of the CARB trajectories were used for calibration constants and the distribution of *V A* product during hard-braking at the end of signalized links.

- Finally, investigators from California Polytechnic State University at San Luis Obispo collected distributions of velocities and accelerations on California freeway on-ramps. A portion of the Cal Poly on-ramp data was used to estimate the distribution of *V A* product during high-power events occurring on on-ramps and to estimate empirical parameters. Separate portions of the CARB data were used to validate the model.

The joint distribution of speeds and velocity-acceleration products is then used with emission arrays derived from output of the Comprehensive Modal Emission Model to calculate hour-averaged emissions for each 30 meter segment of each link. At present, we are using the CMEM, version 1.2, developed under National Cooperative Highway

Research Program (NCHRP) Project 25-11[1,2]. CMEM1.2 was developed for 23 different vehicle/technology classes of LDVs. Extensive tests were carried out on over 300 vehicles chosen to represent the major types of emitters in the existing LDV fleet. CMEM also incorporates other data to help draw associations between the tested vehicles and the fleet at large. CMEM can calculate emissions for different grades and air conditioning loads. We used CMEM to calculate emission arrays for each corresponding to the speed – power matrix of Figure1 for each of the 23 vehicle/technology classes. There are two separate emission arrays:

1) emissions at the specified speed with constant power, and

2) emissions that reflect the difference between jumps from or to the specified power from zero power.

In the case of braking power, the difference is between zero power and the specified power, while for positive power, the jump is from zero to the specified power. The emission arrays were calculated for averge grades of zero, two, four, and six percent.

The Traffic Microsimulator simulates LDVs without regard to grade. As an approximate method to adjust for grade, the vehicle's power is reduced by $g\ V \sin(grade)$ before the power index is computed, where g is the acceleration due to gravity. The result is used with emissions appropriate to the link grade.

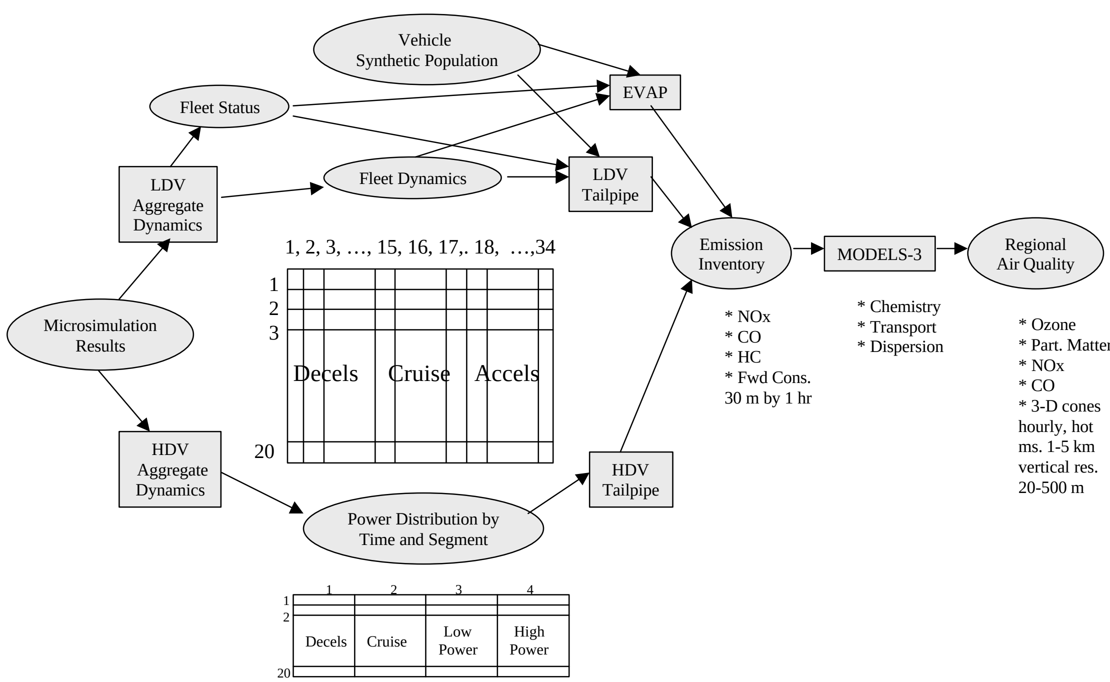

Figure 1. Information flow in the emission module.

The LDV module treats tailpipe emissions from cars, light-duty trucks, and sport utility vehicles. Important aspects include:

- malfunctioning vehicles,
- emissions from starts,
- emissions with variable soak-times,
- emissions from off-cycle conditions that render the pollution controls inefficient, and
- normal driving.

With regard to off-cycle conditions, very high emissions occur at high power demands. The phrase “off-cycle” refers to conditions outside those that occur in the Federal Test Procedure. Emissions in this context are very sensitive to the precise acceleration that occurs at a specific speed.

The evaporative emission module treats:

- running losses,
- resting losses,
- hot soak emissions, and
- diurnal emissions.

The treatment is based on the initially proposed Mobile6 formulation. As opposed to Mobile6, which uses aggregate activities, the stationary emissions in TRANSIMS are car-by-car specific. Running losses are aggregated to 30-meter spatial blocks and one-hour accumulations. The module does use the city-aggregate trip-length distribution.

The HDV dynamics module is drawn from the dynamics module developed for the LDVs, but it is adjusted for the much different power-distribution of the HDVs. The modal emissions were developed by investigators at West Virginia Unversity. They currently have emissions for four age-classes of tractor-trailers, two age classes of 40-foot buses, and one age class of 22-foot buses. The emissions are categorized into four power classes:

- less than minus one-tenth of maximum power,
- between minus one-tenth and plus one-tenth of maximum power,
- between one-tenth and one-fourth of maximum power, and
- greater than one-fourth of maximum power.

The dataset includes no speeds greater than 40 mph, so that emissions above 40 mph were extrapolated from those below. CO_2, HC, NO_x, CO, and particulate matter emissions are estimated.

The Traffic Microsimulator uses grade information to change the acceleration characteristics of HDVs, but the emissions were measured on flat terrain. Consequently, the limits of the power bins that define the various power groups (<-10%, -10% to 10%, 10% to 25%, and 25% to 100% maximum power) are appropriate to zero grades. In order to obtain power groupings that are consistent with the actual grade, we decrease the power limits of the bins by *g V sin(grade)* before assigning the power bin of the vehicles.